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ADVANCED APPROACH FOR TRICHROMY FORMULATION IN CONTINUOUS DYEING

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ABSTRACT

Reactive dye fixation to color yield of dyed cellulosic fibre significantly depend on the dye diffusion extent into the fibre polymer matrix. In case of pad-dyeing process dye diffusion exerts more significant influence on dye fixation, consequently color yield takes place. Dye selection concepts based on performance tests requires tedious experimental work which remains always very difficult in continuous processes. In order to overcome this problem, this research work will provide an appropriate platform to understand and optimize the diffusion coefficient which plays important role in best trichromy selection by converting visual performance tests into data. The dye diffusion extent of reactive dyes into the fibre in pad dyeing using Kubelka-Munk equation is the correct for optimization and judicious dye selection. Dye diffusion index influences the dye fixation, ultimate color yield to color fastness of dyed fibre to digital color values. Various characterization techniques like affinity of different dyes by capillary test method, diffusion extent of individual dye by kubelka- munk equation method, drop test of individual dye its conversion into data form and dry migration of these dyes using disc method are used in this study.

KEYWORD: Trichromy, continuous dyeing, diffusion, Kubelka-Munk,

INTRODUCTION

Colors are antistatic part of human life. Colored compound containing a chromophore and auxochrome acquires an additional property of getting bound to textile fibre.In other word colored compound containing auxochrome become dye. Application of dye depend on the selection of substrate type. For cotton substrate reactive and vat dyes are used to produce desired colour effect. A simple method of applying dyes to cotton fabrics involve the dissolution of the dye in water entering the fibre material in the dye solution and slowly heating system when the dye dissolve in water is gradually transferred to the fibre because of higher affinity of dye for fibre than water . But the disadvantage of dyeing by this process is poor fastness properties. In trichromy recipe, dyes are specially selected with optimum reactivity, substantivity and diffusion behaviour to produce reproducible shade. The best guide to the dyeing performance of a reactive dye can be obtained by considering the compatibility of the dyeing profiles & diffusion behaviour of the dyes selected, similar properties to be identified and used in combination to support right first time production. Dye diffusion exerts a significant influence on dye fixation, ultimate color yield and colorfastness of a dyed fiber. Therefore, dye diffusion should be considered for dye selection and color matching as one of the primary parameters. In this study the properties of reactive dyes like capillary action, drop migration action dye diffusion property and thermo migration properties are discussed in detail. The main objective of this study is to develop a robust trichromy combination to produce reproducible shade in bulk continuous dyeing method based on its dye diffusion property.

Following tests were carried out here in this study-

1. Studied affinity of different dyes by capillary test and drop test of individual dye, its conversion into data form method.
2. Studied diffusion extent of individual dye by kubelka- munk equation method.
3. Dye migration of these dyes using disc method.

Here we have studied the effect of diffusion on selected trichromy recipes of a particular shade i.e. Khaki performance in terms of following parameters –

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Fastness Properties
Water fastness
Washing fastness
Rubbing fastness
Perspiration fastness

Shade Quality Parameter
Color Difference ('dE')
Color Inconsistancy ('CI")
Metamerism index (MI)

Cost
Experimental:
1. Material – 100 % Cotton Fabric (40C*40C-142*72-148-PLAIN-134) material were used to develop khaki shades

2. Dyes and chemicals-

Table 1: List of all classes of dyes used

Commercial Name	**Class of Dye**
Ciba Red C2BL	Reactive
Ciba Yellow NC	Reactive
Ciba Olive CA	Reactive
Ciba Olive NC	Reactive
Levafix Fast Red CA	Reactive
Levafix Amber CA	Reactive
Synozol Yellow CPLP	Reactive

Table 2: List of Auxiliaries used for dyeing

Commercial Name	Action	Supplier
Sarasol AMC	Antimigrating agent	sarex
Common salt	Exhausting Agent	Future Tech & Sham Salt
Metaxil WCD	Wetting Agent	Croda
Acetic Acid	pH maintaining	N.S.Dyes & Chemical
Alcosperse AC	Dispersing Agent	Huntsman
Caustic	Alkali	Mulkraj & Rajendra
Resist salt	Mild oxidising agent	Clarient
Soda ash	pH maintaining and Fixing agent	GHCL Limited
Polypx TDS	Soaping agent	Shiva dyes & chemical

PADDING CHEMICAL RECIPE

Sarasol AMC - 100 gpl
Common salt - 75 gpl
Metaxil WCD - 10 gpl
Acetic Acid - 20 gpl
Alcosperse AC - 10 gpl

Table 3: Padding Condition

Pressure	2 Bar
Speed	8 m/min
Temperature	Room Temperature

Table 4: Drying Condition

Drying Condition	2 Bar
Temperature	120^0C
Speed	2m/min
IR	100 %
Air Flow (RPM)	1800

DEVELOPING CHEMICAL RECIPE

Pressure -2 Bar
Common Salt -250 gpl
Soda Ash -20 gpl
Caustic -13.5 gpl
Resist salt -5 gpl

Table 5: Developing Condition-

Steam Temperature	100^0C
Steam Pressure (Bar)	1
Mangle Pressure (Bar)	1
Squeeze Roll Pressure (Bar)	1
Trough 1	Normal Water
Trough 2	60^0C
Winding Tension (psi)	10-15

Table 6: Wash-Off Condition-

Polypex TDS (Soap)	2 gpl
Temperature	90^0C
Time (min)	2

PDPS (Pad Dry Pad Steam) process has been used with pick-up 65% to 70%. In Mathis padder & padded with trichromy recipe at room temperature. After padding padded fabric dry in Mathis dryer at 120^0C with speed 2m/min and developed by padding with developing recipe in Mathis laboratory steamer having steam temperature 100^0 C, speed 4 m/min, after chemical treatment fabric is treated first with water at room temperature and then 60^0C water. After developing fabric were washed as per recipe mention in table.

Washing-Off

Dyed fabric was rinsed with cold water, hot tap water and soap with 2 gpl Polypx TDS at 90^0C for 2 min, then rinsed with hot water until bleeding stopped, the fabric was finally rinsed with cold water and dried in cylindrical dryer.

Measurement:

Drop test, wicking test, dye migration test and extent of dye diffusion were measured in running dyes and develop three shades of Khaki. Various other parameters were also checked as mentioned below-

Fastness Properties

Water fastness Test (ISO 105E01)
Washing fastness Test (ISO 105 C06)
Rubbing fastness (ISO 105 X12)
Perspiration fastness (ISO 105 E04)
Light Fastness (ISO 105 B02)

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Shade Quality Parameter
Color Difference ('dE')
Color Inconsistancy ('CI')
Metamerism index ('MI')
Cost
Drop Test:
Objective – To check the compatibility of dyes by drop test
Equipment & Accessories - Fabric of 40's, dropper, hood for tightening the fabric
Methodology -
1. First we have tightened the fabric by hood.
2. Then put two drops of dye solution with the help of dropper
3. After that put a drop by drop water until movement of dye has been stopped & water moves further.
Measurement – measure drop diameter of individual dye in combination

Wicking Test:
Objective- Compatibility of dye stuff by wicking test method
Equipment & Accessories -
Fabric of 40's, Four measuring glass beaker, In-house prepared wicking test, dye stuff solution (5 gpl), Pencil, scale

Methodology –
1-First prepare fabric strip for test
2-Mark 2 cm in stripe
3-Dip 1 inches of stripe in dye solution for 10 min
4-Measure wicking height by scal

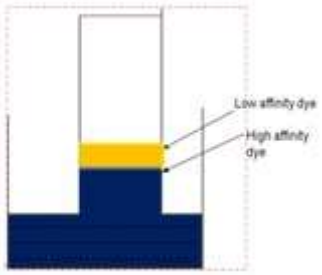

Figure 1: Wicking Height Test

Migration Test:
Objective- This test method provide a means of assessing the migration property of a pad liquor system containing dye.

Equipment & Accessories-
Fabric of 40's, watch glass, laboratory dryer, laboratory padder, dye stuff solution (gpl), Spectrophotometer

Methodology-
Fabric was impregnated with colorant and auxiliaries then fabric was padded and dried partially covering with a watch glass and partial drying was done, and therefore migration to occur. The degree of migration was evaluated by spectrophotometer. In house modified test method based on AATCC Test Method 140-2001 was followed .

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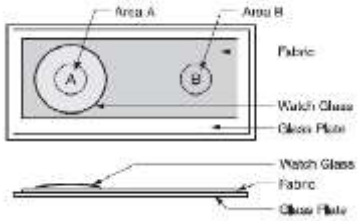

Figure 2. Migration Test

Extent of dye Diffusion:
Objective- This test method provide a means of assessing the extent of diffusion of a pad liquor system containing dye.

Equipment & Accessories –
Fabric of 40's, laboratory dryer, laboratory padder, dye stuff solution (gpl), Spectrophotometer
Methodology -
Color strength K/S value -was obtained at maximum absorption peak by color i7 spectrophotometer with illuminant D65, UV included, specular component included at 10^0 Observer condition. Each sample was conditioned 30 min before measurement at 20^0C+/-2 and 65 +/-2% RH.

Procedure for Diffusion Measurement:
To determine K/S value of the reference fabric, sample was padded with known concentration of trichromy recipe with 65 % to 70 % Pick- up in Mathis padder. The preparation of dye solution and setting up liquor pick-up were precisely done. The sample was then dried for 120^0C at speed 2 mt /min in Mathis dryer. At this stage maximum numbers of dye molecules are on the surface of fabric. The color strength of reference fabric is then measured by spectrophotometer.

Determining K/S Diffusion index, another dry sample were developed in Mathis developing range with developing condition as mention in Table 5, wash-off and dry. At this stage less dye molecules are on surface of fabric and then color-strength (K/S diffusion index) was measured by spectro-photometer.

Studied diffusion extent by kubelka –munk equation
%D (Extent of dye diffusion) = 100- k/s diffusion index/k/s reference x100
Study of Khaki Recipe

Table 7: List Of Khaki Recipe

RECIPE	DYES	GPL
Khaki 9	Ciba Olive NC	30
	Levfix Fast Red CA	1.12
	Levafix Amber CA	1.5
Khaki 10	Ciba Olive NC	3.5
	Ciba Red C_2BL	1.02
	Ciba Yellow NC	2.0
Khaki 11	Ciba Olive CA	15.7
	Levfix Fast Red CA	8.35
	Synozol Yellow CPLP	2.92

Observations:
It is observed from below graphical representation, Khaki10 which is std & Khaki 11 having least % average mean dye diffusion, average mean deviation of capillary and drop test, color value function supporting trichromy selection below of Khaki 11 is best .

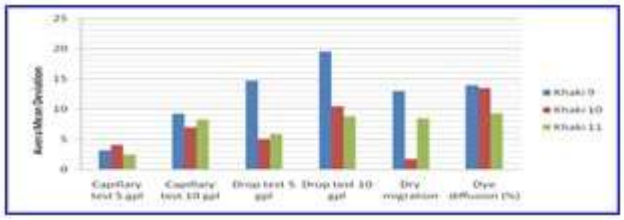

Figure3: Average Mean Deviation of Dye Diffusion Extent of Khaki Recipe

EFFECT OF DYE DIFFUSION ON COLOR VALUE FUNCTION

It is observed that Khaki11 is showing least DE value, metamerism index, and constant recipe.

Table 8

	L	a	b	c	H	DE	CI(12)	CI(13)	CI(23)	MI(12)	MI(13)	MI(23)
STD Khaki 10 (UL35)	56.8	5.95	18.47	19.41	72.16		3.54	2.43	1.59			
STD Khaki 10 (A -10)	57.03	8.47	18.59	20.43	65.5							
STD Khaki 10 (D-65)	55.42	4.99	16.31	17.05	73							
Khaki 9 (UL35)	57.47	5.2	18.68	19.39	74.44	1.03	3.25	3.27	1.71	0.42	0.86	0.9
Khaki 9 (A-10)	57.51	7.77	19.18	20.69	67.95	1.24						
Khaki 9 (D65)	55.9	5.08	16.48	17.25	72.86	0.25						
Khaki 11 (UL35)	57.22	5.82	18.38	19.28	72.43	0.23	3.54	2.43	1.58	0.01	0.03	0.04
Khaki 11 A -10)	57.44	8.35	18.49	20.29	65.69	0.22						
Khaki 11 (D65)	55.86	4.87	16.24	16.95	73.31	0.24						

Effect of Dye Diffusion on Water Fastness:

It is observed from graphical representation of data that all recipe shows good water fastness result.

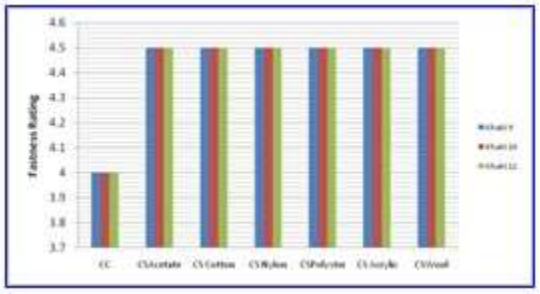

Figure 4: Colorfastness to Water of Khaki Recipe

Effect of Dye Diffusion on Washing Fastness:

It is observed from below table and graphical representation of data that all recipe shows good washing fastness.

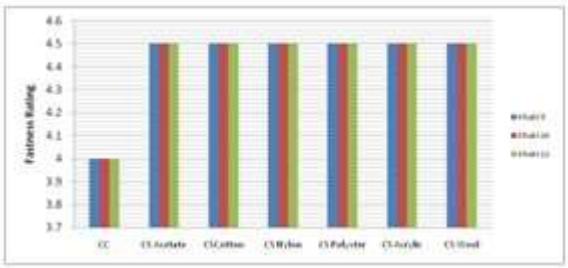

Figure 5: Colorfastness to washing of Khaki Recipe

Effect of Dye Diffusion on Perspiration (Acid) Fastness:
It is observed from below graphical representation of data that all recipe shows good perspiration fastness.

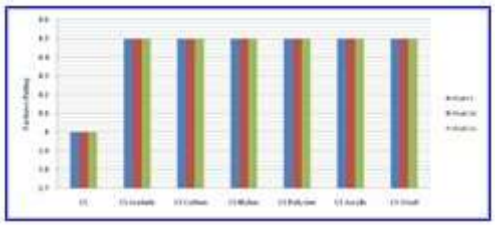

Figure 6: Colorfastness to Acid Perspiration of Khaki Recipe

Effect of Dye Diffusion on Perspiration (Basic) Fastness:
It is observed from below graphical representation of data that all recipe shows good perspiration fastness.

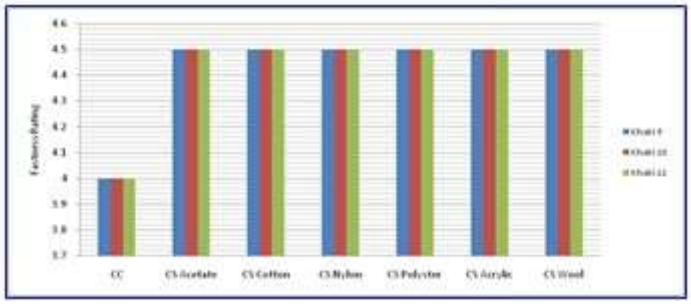

Figure 7: Colorfastness to Alkaline Perspiration of Khaki Recipe

Effect of Dye Diffusion on Rubbing Fastness:
It is observed from below graphical representation of data that rubbing fastness of trichromy khaki 9 & 10 shows rating 4.5 in the scale of 5.

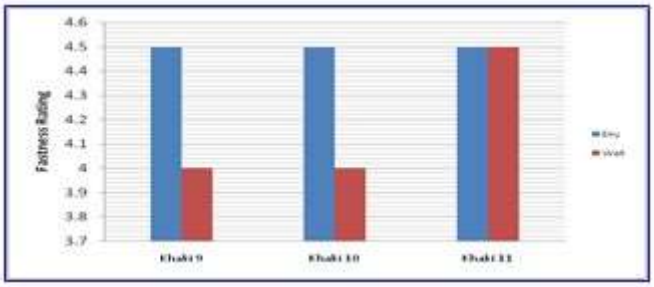

Figure 8: Colorfastness to Rubbing of Khaki Recipes

Khaki Color Light Fastness Result
It is observed from below and graphical representation that there is no change in light fastness result.

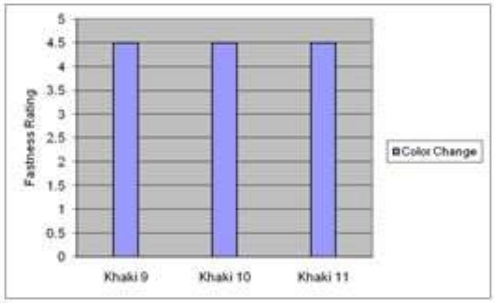

Figure 9: Colorfastness to Light of Khaki Recipe

Effect of Dye Diffusion on Recipe Cost:

It is observed from below table and graphical representation that Khaki 11 recipe shows highest recipe cost though its average mean deviation of dye diffusion is least.

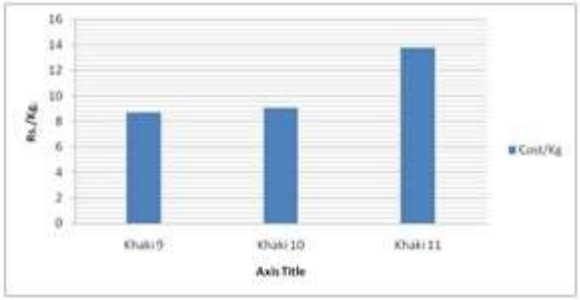

Figure 10 Cost Comparison of Khaki Recipe

CONCLUSION

The research focused on diffusion by applying dye diffusion extent of reactive dyes into the cotton fibre/fabric in pad dyeing method. Diffusion is the correct way for optimization and judicious trichromy dye selection. The effect of diffusion extent on shades khaki was studied and results are summarized as- In case of Khaki shade, observed that among various Khaki recipes, least average mean deviation of diffusion is for Khaki 11 (Ciba Olive CA-15.7gpl; Levafix Fast Red CA-8.35gpl; Synozol Yellow CPLP- 2.92gpl) i.e. 9.29 % .This recipe is also found best in terms of fastness, colour value functions. From the above results it is concluded that the best trichromy formulation is correlated with diffusion property of individual dyes and best trichromy recipe is found where deviation of diffusion is minimum. The cost study indicates that this dyeing recipe selected in this way is higher in dyeing cost Rs13.79. Fastness ratings of Khaki11 are more than 4 on the scale of 1-5.

From the above it is concluded that diffusion plays a major role in selection of best trichromy recipe. For dark shade category this type of trichromy formulation is also economical than medium & light shade category.

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